JAN MCLIN CLAYBERG

PATENT AND TECHNICAL TRANSLATION

JAN MCLIN CLAYBERG •
OLAF BEXHOEFT ••

ACCREDITED BY AMERICAN TRANSLATORS ASSOCIATION
• GERMAN AND FRENCH TO ENGLISH
•• ENGLISH TO GERMAN

5316 LITTLE FALLS ROAD
ARLINGTON, VIRGINIA 22207

TELEPHONE (703) 533-0333
TELECOPIER (703) 533-0334
E-MAIL: JMC@CLAYBERG.COM

JUN 15 2004

June 12, 2004

DECLARATION

The undersigned, Olaf Bexhoeft, hereby states that he is well acquainted with both the English and German languages and that the attached is a true translation to the best of his knowledge and ability of the German text of PCT/EP03/oo178, filed 01/10/2003 and published 07/17/2003 under No. WO 03/058365 A2, and ten (10) amended claims.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

Olaf Bexhoeft

Olaf Bexhoeft

EXPRESS MAIL NO. EV512063681US

MAILED 02 JUL 2004

HEATING DEVICE COMPRISING A FLEXIBLE HEATING ELEMENT

The invention relates to a heating device having an electrical heating conductor arrangement, which is integrated into a flexible heating element and can be connected to a supply voltage via a connector cable, a heating circuit formed by the heating conductor arrangement and further elements, including a control member for a heating current, and a triggering circuit with a control loop connected to the control member for varying the heating current and regulating the temperature, wherein the control of the control member takes place as a function of a deviation between an actual value and a rated value.

Such a heating device is approximately disclosed in EP 0 562 850 A2, which relates in particular to a circuit for the protection against overheating of the electrical heating conductor arrangement integrated into the flexible heating element. The triggering circuit provided there furthermore also has a temperature control loop, by means of which a heating current is varied by means of a control member in the form of a thyristor for maintaining a desired temperature. Other embodiments of the control member are also mentioned, for example a mechanical, thermal or other electronic switch. However, no detailed information regarding the structure of a control loop is provided.

The invention is based on making available a heating device of the type mentioned at the outset, which offers advantages in particular in view of the design of the control loop.

This object is attained by means of the characteristics of claim 1. In accordance therewith it is provided that the triggering circuit is furthermore coupled via a coupling

branch to the heating circuit for picking up an electrical measurement value -current or voltage - which is a function of the temperature of the heating conductor arrangement, and has a control loop with a digitizing stage of a digital circuit arrangement, and that the triggering circuit is embodied in such a way that the control of the control member for regulating a set temperature of the heating element takes place on the basis of data developed by the digitizing stage.

This embodiment of the triggering circuit with a control loop having a digitizing stage and by means of which the regulation of the set temperature takes place on the basis of developed digital data allows an accurate and dependable temperature regulation, which can also be designed without difficulties to meet different requirements, for example regarding the type and speed of the regulation of the temperature, or as a function of the type of the flexible element (for example blanket or pad or heated mattress pad). The digital circuit arrangement in this case is preferably a micro-controller, but can also be, for example, a specially constructed digital circuit arrangement, such as an ASIC, a CMOS gate, or the like.

For developing the actual value it is advantageously provided that the measured quantity is picked up by means of a voltage divider formed in the heating circuit, which is constituted on the one hand by means of the heating conductor arrangement constituting a temperature-dependent resistor, and on the other hand by means of at least one resistor element. The heating conductor arrangement, which is provided anyway, is also used as a temperature sensor.

Here different structural variations consist in that the measured quantity is conducted indirectly or directly to the digitizing stage via a feed branch for developing a digital actual value. In this connection a wireless path for transmitting the measured quantity is also conceivable.

An advantageous structure of the triggering circuit, in particular the control loop, results in that the measured quantity is supplied to an analog time function element arranged upstream of the digitizing stage and having a resistor/capacitor circuit, that the digitizing stage has a time-measuring element for developing the actual digital value, and that the actual digital value corresponds to an actual time value until a preset or presettable charge voltage of the capacitor has been reached, that in the digitizing stage a rated time value can be preset or is presettable as the rated value, and that for heating, the triggering of the control member takes place as a function of the deviation of an actual time value from the rated time value.

Further advantageous measures consist here in that one connector of the capacitor is coupled via a charging resistor to a pole of the supply voltage, and that the other connector is coupled to the heating circuit via the coupling branch, and that for detecting the measured quantity and developing the actual value the control member is triggered by means of the digital circuit arrangement.

If it is provided that the capacitor is connected to the supply, voltage by a rectifier, it is possible, for example with a line supply voltage, to advantageously utilize half-waves for triggering and developing the actual values and/or rated values.

A further advantageous embodiment of the structure and the performance of the regulation consists in that for developing the rated value the control member is brought into its non-triggered state in which it interrupts the heating circuit, and the other connector of the capacitor is connected to a further voltage divider for picking up a component voltage which can be set to correspond to a desired temperature, and for developing the rated value from the component voltage.

In this case individual periods of time of the control can be unequivocally subdivided in that the pick-up of the component voltage takes place by means of a switching member which is temporarily triggered via the digital circuit arrangement, and that the developed rated value and/or the developed actual value is/are stored for performing a rated/actual value comparison in the digital circuit arrangement.

The dependability and accuracy of the temperature regulation is aided in that the digital circuit arrangement is designed for generating a reference value as the common reference value for the rated value and the actual value. By means of this step it is possible, for example by means of appropriate programs in the digital circuit arrangement, in particular a micro-controller or a micro-computer, to also detect the type and/or location of errors, or to include suitable correction values.

In this case an advantageous embodiment of a simple, dependably functioning construction consists in that for developing the reference value the control member and the switching member are placed in their interrupted state and the capacitor, which is connected via the one or the other connector with the digital circuit arrangement, can be discharged by means of the latter for performing the reference measurement, and is subsequently charged

via the charging branch, the coupling branch and the resistor element of the heating circuit, and that in the process the time until the charge voltage of the capacitor has been reached, measured by means of the time-measuring member of the digital circuit arrangement, is stored as the reference value. In this case the time function element of the resistor/capacitor circuit is used not only for developing the actual value and the rated value, but also for developing the reference value, from which increased dependability ensues.

A structure which is advantageous for performing the temperature regulation consists in that the digital circuit arrangement is embodied in such a way that, for temperature regulation, initially the reference value during a supply half- wave is determined, and thereafter the rated value and the actual value are determined in the course of respective further half- waves, and the temperature is adjusted on the basis of a comparison of the rated value and the actual value and, following an intermission in which the triggering of the control member is interrupted, the mentioned steps from the reference value development to the intermission time are cyclically repeated.

The invention will be explained in greater detail by means of exemplary embodiments represented in the drawings. Shown are in:

Fig. 1, a schematic representation of an electrical circuit of a heating device, and

Fig. 2, voltage curves of a time function element, applied over time, for deriving an actual value, rated value and reference value.

A heating device with a flexible heating element 1 is represented in Fig. 1, for example in the form of a heating blanket, a heating pad or a heated mattress pad, into which

a heating conductor arrangement has been integrated and a safety fuse F1 is housed, and having a triggering circuit 2 acting on a heating circuit 3, by means of which a heating current iH flowing through the heating circuit 3 with the heating conductor arrangement 1.1 can be varied for setting a desired temperature.

The heating circuit 3, which is connected to a supply voltage UV, for example a line voltage, an otherwise transformed voltage or a d.c. voltage, and which can be cut off from it by means of switches S1, S2, has, following the heating conductor arrangement 1.1 and the safety fuse F1, a diode, which is connected in the conducting direction of a positive half-wave, a control member THY1 in the form of a thyristor or triac, or other semiconductor switch, or electronically operable mechanical contact, as well as a voltage divider resistor R21, which is connected to ground with its connector remote from the control member THY1 and forms, together with the heating conductor arrangement 1.1, a voltage divider. The heating conductors Rhz1, Rhz2 of the heating conductor arrangement 1.1 are insulated from each other, preferably by means of an insulator which melts at a suitable temperature, and are connected with each other as the inner conductor and the outer conductor of a heating cord, as is known per se, by means of which a compensation of the electromagnetic field is also achieved. The heating conductor arrangement 1.1 is connected at, for example two, connecting points A, B in the edge area of the flexible heating element 1, or to a short piece of cable with a plug/connector unit, and is releasable from the heating circuit 3, or is connected with the latter by means of a fixed connector cable. The safety fuse F1 can also be arranged outside of the flexible heating element 1 in the heating circuit 3, for example in the plug/connector unit. The heating resistors Rhz1, Rhz2 have a temperature-dependent

resistance, for example with a positive temperature coefficient (PTC effect) or a negative temperature coefficient (NTC effect), so that the voltage divider formed together with the voltage divider resistor R21 is temperature-dependent. Several heating circuits 3 can be provided in parallel or in series, wherein several heating cords are correspondingly arranged in the heating element 1.

The triggering circuit 2 is connected via a coupling branch 5 for picking up the component voltage developed by means of the voltage divider from the voltage divider resistor R21 and the heating conductor arrangement 1.1, as well as via a triggering branch 9 to a control input of the control member THY1, and has a digital circuit arrangement 2.1, which is powered via an energy supply device 4 and is designed, for example, as a micro-computer, micro-controller, special integrated circuit arrangement (ASIC), CMOS gate or the like, as well as furthermore a time function element, integrated into charging branch 7 and a rated value branch 6 and consisting of a resistor/capacitor circuit R7, C6 and a further voltage divider 8 connected to the supply voltage UV and having fixed resistors R12, R15 and an adjustable resistor P1, wherein a further diode D2 is inserted in the conduction direction into the positive potential connection to the supply voltage UV. In this case the further diode D2 is arranged in such a way that the entire triggering circuit 2 is connected by means of the latter to the supply voltage UV.

An adjustable component voltage, which can be selected in accordance with a desired temperature of the heating element 1, is picked up at the further voltage divider 8 between the fixed resistors R12, R15 for constituting the rated value branch 6 and can be set by the adjustable resistor in the form of the potentiometer P1. Here, the potentiometer P1 is

located between the fixed resistor R15 on the ground side and the ground Gnd. The component voltage picked up at the further voltage divider 8 is applied to the capacitor C6 via a controllable switch S3, which for opening and closing is connected to the digital circuit arrangement 2.1 via a connecting switch. Thus, the capacitor C6 is connected with its one connector to the positive pole of the supply voltage UV via the charging resistor R7 for charging, and with its other connector to ground via the controllable switch S3 and the fixed resistor R15 and the potentiometer P1 for constituting the rated value branch 6 wherein, for developing a rated value, the rated value branch 6 can be temporarily closed by means of the controllable switch S3 in accordance with a triggering algorithm fixed in the digital circuit arrangement 2.1. The connector of the capacitor C6 connected with the charging resistor R7 is moreover connected with an input connector of the digital circuit arrangement 2.1 for detecting the charge voltage and conducting it to a digitizing stage 2.11, while the other connector of the capacitor C6 is preferably connected to a discharge connection (Discharge) of the digital circuit arrangement 2.1 in order to perform a complete controlled discharge of the capacitor C6. This other connector of the capacitor C2 is furthermore connected via the coupling branch 5 with a resistor R14 for picking up the component voltage at the resistor R21 of the heating circuit 3, i.e. an actual measured quantity as a function of the temperature of the heating conductor arrangement 1.1, and thus of the heating element 1, wherein the connecting point lies in the heating circuit 3 between the control member THY1 and the voltage divider resistor R21. The triggering branch 9 contains a resistor R11 and is connected to a control connector Trig1 of the digital control circuit 2.1 in order to perform a temperature regulation of the heating element 1 as a function of a rated value/actual value

comparison, wherein suitable regulating algorithms can be preset or programmed by means of the digital circuit arrangement 2.1.

Alternatively the discharge connection Discharge can also be omitted. Instead of generating component voltages via the resistors R7 and R12, it is also possible to apply corresponding d.c. voltages, which are separated from the load circuit (heater), so that the resistors R7 and R12 can be dispensed with. Furthermore, various rated values can also be preset in the digital circuit arrangement and picked up via assigned connections, which can be suitably contacted by means of a change- over switch. The resistors R12, R15, P1 and the switch S3 can be replaced by this. In that case, pre-setting of the rated value does not take place via the changed resistor P1, but by means of the change-over switch. For example, it is possible to provide a temperature-stabilized time cycle or a reference time in the digital circuit arrangement 2.1 for this.

On the other side, the digital circuit arrangement 2.1 is connected via a connector Vcc to the energy supply device 4, and by means of a ground connector Gnd to ground potential. Moreover, further connections of the digital circuit arrangement 2.1 with the energy supply device 4 exist via a synchronizing connection Sync, a display connection Anz, as well as a reset connection Reset, wherein a resistor R2 is connected to the synchronizing connection Sync, and a display, by way of example in the form of a light-emitting diode LED, as well as a resistor arrangement R3, are connected to the display connection Anz. The energy supply device 4 is connected on one side to ground, and on the other side to the supply voltage UV via a resistor R1 and the further diode D2.

The procedure in connection with the temperature regulation will be described in greater detail in what follows by means of the heating device represented in Fig. 1 and of charge curves of the capacitor C6 represented in Fig. 2, from which the actual value at various temperatures of the heating conductor arrangement 1.1 and the rated value are derived. The reference value, the rated value and the actual value are respectively determined from the charge curves of the variously wired capacitor C6, which is controlled by means of the digital circuit arrangement 2.1, wherein the charge times of the capacitor C6 to a defined charge voltage are determined by means of a digitizing stage 2.11 provided in the digital circuit arrangement 2.1. A digital time- measuring member with a fixed time cycle and a counter is provided in the digital circuit arrangement 2.1. By means of a comparison of the actual value in the form of an actual time value with a rated value in the form of a rated time value a decision regarding the supply of the heating current iH is made by means of the control member THY1, i.e. regarding heating or not heating.

Large supply voltage ranges of approximately 100 V to 250 V, as well as frequency ranges of customary line supply voltages of approximately 50 to 60 Hz are covered in a simple way by means of the present steps for developing the actual value and the rated value, wherein the customary resolution of the digitizing stage 2.11, or of the digital time-measuring member is sufficient, but can also be slightly enlarged, if desired. The increase in resolution can take place here simply by increasing the cycle frequency, for example automatically, with a corresponding switching of the supply voltage. For example, this can take place as a function of the dynamic reference value in the memory of the digital circuit arrangement 2.1, which is set in accordance with the supply voltage.

For determining the reference value, the capacitor C6 is here completely discharged via the connectors Ist/Ref and Discharge, for example during a negative half-wave of the supply voltage UV, which is the line voltage, for example. The controllable switch S3 and the power circuit breaker in the form of the control member THY1 are not triggered, i.e. are open during the reference measurement. A zero voltage passage of each positive half-wave is detected by means of the synchronizing connection Sync, and following voltage zero the charging process of the capacitor C6 takes place as a function of the resistors R7, R14, R21 and the further diode D2 until a digital switching level has been reached at the reference input of the digital circuit arrangement 2.1. At a line frequency of 50 Hz, the charge time, which constitutes the reference value, is for example 5.8 ms in accordance with Fig. 2.

The controlled switch S3 is not triggered for developing the actual value, i.e. it remains open, while the control member THY1 is triggered, i.e. the heating circuit 3 is closed. Because of the current flow over the heating resistors Rhz1 and Rhz2 which are constituted by the heating conductors, over the safety fuse F1, the diode D01, the control member THY1 and the voltage divider resistor R21, a voltage drop U21, which is proportional to the temperature, is created at the voltage divider resistor R21. For example, the component voltage in the form of the voltage drop U21 is approximately 1 V at a heating conductor temperature of 20° C (peak of the positive sinus half-wave), and at the maximum temperature (80° C) approximately 0.7 V. Because of the parallel increase of the positive charging voltage at the charging resistor R7 and the rise by means of the component voltage U21, the charging process of the capacitor C6 until the switching level is reached is reduced

to a charging time, or an actual time value, of approximately 4.7 ms at 20° C. If, because of the heating of the heating conductor arrangement 1.1 to 70° C as a result of the PTC effect, the component voltage U21 is reduced to approximately 0.75 V in the maximum of the sinus half-wave, the charging process of the capacitor C6 takes place in approximately 5.0 ms.

For developing the rated value in the form of the rated time value, the charging voltage of the capacitor C6, with the control member not triggered, i.e. with an open heating circuit 3, and switched-on, i.e. closed controllable switch S3, is raised by the potentiometer P1 by approximately 0.7 V (maximum of the positive sinus half-wave) at the maximum temperature setting (80° C). This corresponds to the component voltage U21 at the maximum temperature. This results in a charging time of the capacitor C6 until the switching level is reached of 5.1 ms (rated time value at 80° C). In this case the rated value branch 6 results because of the structural components of the further diode D2, resistor R7, capacitor C6, controllable switch S3, resistor R15 and adjustable resistor P1, together with the resistor R12 of the further voltage divider 8, wherein the controllable switch S3 is triggered by means of the digital circuit arrangement 2.1 via the connection Switch.

In the course of the temperature regulation, first the reference value is determined, thereafter the rated value and the actual value are determined as rated time value and actual time value. By means of the comparison of the charging times at the capacitor C6 performed on the basis of the derived digital data of the actual time values and the rated time value a decision regarding heating or not heating is then made. When reaching the maximum temperature, identical charging times result at the capacitor C6 (wherein the component voltage U21 is 0.7 V), i.e. in the present case 5.1 ms. The triggering of the control member

THY1 is thereupon interrupted, and a pause of approximately 1 s is inserted. Thereafter the reference, rated and actual values are respectively determined with three line half-waves. By means of a further comparison a decision regarding heating or not heating is again made. In case of non-heating a pause of 1 s is again inserted. This sequence is repeated.

In particular, the comparison of the rated value and the actual value in the digital circuit arrangement 2.1 can also be provided to other regulating algorithms in order to provide the heating current iH in the heating circuit 3 via the control member THY1 as a function of a desired chronological temperature behavior, and/or as a function of the type of the flexible heating element 1, for example a heating blanket, a heating pad or a heated mattress pad. A suitable control algorithm can be easily programmed by means of a micro-computer or micro-controller, wherein it is possible in particular to satisfy safety regulations.

One possibility of temperature regulation consists in realizing a rated value increase and a controlled rated value decrease to a rated value. Because of the thermal delay of the rise of the surface temperature of the heating element to the heating conductor temperature because of poor heat conduction of the materials of the flexible heating element 1 it is desirable, for example, to improve the temperature rise. A solution for this is offered by the determination of a rated temperature value as a function of time after the heating device has been switched on. For achieving an excess surface temperature of an already pre-warmed heating element, the rated value for the regulation is predetermined by an optimized method. By determining the difference between the rated value and the actual value this can lead to a calculated temporary reheating as a result thereof after the rated temperature value has been reached. Alternatively it is also possible to fix a calculated higher rated value for

the regulation, for example from a comparison of the rated and the actual temperature. Thus, if the rated value/actual value difference at the switch-on time is large, a large rated value increase is fixed. The increase is then maintained constant or is varied, for example, until the actual value agrees with the increased rated value. Thereafter a temperature gradation derived from the rated value increase is then started. In this way there is the advantage that the surface temperature does not break down. But if in contrast to this the rated value/actual value difference is the same at switch-on as during the operation, no rated value increase and no controlled rated value reduction to the rated value are performed. Appropriate parameters for gauging the rated value/actual value difference can be stored in the digital circuit arrangement 2.1. Depending on the type of the flexible heating element 1, for example heating pad, heated mattress pad or heating blankets, it is here also possible to provide a different calculating method for the rated value increase. For example, this can be realized by the evaluation of stored software or by means of programmed digital inputs, or also by a time-controlled connection with or switching to another rated value stage.

The already described reference measurement can be advantageously employed for the detection of errors. To this end, the measured reference value of the charging time can be compared with the rated value and/or the actual value, and by means of the results of the comparison and on the basis of already known, or stored, or input values it is possible to detect an error in the electronic device, for example a short circuit in the control member THY1, or in connection with the controllable switch S3. The errors can be exactly localized and displayed by means of plausibility comparisons. The display can be designed as a simple luminous indicator up to a variable display indicator, wherein triggering by means of the

digital circuit arrangement 2.1 can be designed in different ways, for example as a blinking warning display, or also acoustically.

Switching off the heating device can take place by means of a single or multiple time switch, wherein switch-off times can be fixedly integrated, or separately switchable. During extended operations a temperature reduction can be provided by means of an appropriate programming of the digital circuit arrangement 2.1 in order to prevent burning of the skin because of continuously high surface temperatures of the heating element. For this purpose it is possible to provide, starting at a defined rate temperature value, a time-dependent step-down of the rated value, or even the switching off of the heater.

By means of the display device, defined herein as a display unit LED, for example, the various operating states of the heating devices, for example reduction of the rated value, timed shut-off, or the like, can be indicated to the user in a multitude of ways, for example by means of color, numbers, symbols, texts or the like. In the course of this it is possible to realize a blinking operation, changing colors, flash indicator or the like, as well as an indication by means of sound, voice or vibration. For example, a vibrating alarm can be provided in the heating element or in a switch on the cord until the lowering of the rated temperature value, in order to prevent, for example by a repeated operation, the user from falling asleep during critical phases.